

Geologic CO₂ Sequestration : Assuring Safe Effective Long Term Storage

Ian Duncan

**Gulf Coast Carbon Center
University of Texas at Austin,
Bureau of Economic Geology**



**BUREAU OF
ECONOMIC
GEOLOGY**



Acknowledgements

- Gulf Coast Carbon Center researchers: Susan Hovorka, Tip Meckel, Jiemin Lu, JP Nicot, Katherine Romanak, Changbing Yang, David Carr, Becky Smyth, Jong-Won Choi
- BEG Associate Director: Ian Duncan
- BEG Director: Scott Tinker
- Funding organizations: The Department of Energy National Energy Technology Laboratory, Southeast Regional Carbon Sequestration

GCCC sponsors



BUREAU OF
ECONOMIC
GEOLOGY



The Questions Facing Us 12 Years Ago

(1) Will sequestration work

(2) Is it safe, secure long term storage

(3) Does the US have enough capacity for sequestration



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Why we believe that CO₂ Sequestration will work

**Natural gas reservoirs have kept gas in
the subsurface for tens of millions of years**



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Why we believe that CO₂ Sequestration will work

**The 37 year plus record of CO₂ injection
into depleted oil fields (CO₂-EOR)**

**~ 600 million tons of CO₂ transported in
pipelines in the US**

~ 1,200 million tons of CO₂ injected



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Why we believe that CO₂ Sequestration will work

**No known significant environmental
issues**

Excellent safety record

**Better than 99% retention of CO₂ in
reservoir**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Why we believe that CO₂ Sequestration will work

**Bureau of Economic Geology's
DOE funded Field Projects:**

Frio I

Frio II

SACROC

Cranfield Phase II

Cranfield Phase III



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Frio I Brine Pilot:

Funded by
DOE NETL



Frio Brine Pilot Research Team

- Bureau of Economic Geology, Jackson School, The University of Texas at Austin: Susan Hovorka, Mark Holtz, Shinichi Sakurai, Seay Nance, Joseph Yeh, Paul Knox, Khaled Faoud, Jeff Paine
- Lawrence Berkeley National Lab, (Geo-Seq): Larry Myer, Tom Daley, Barry Freifeld, Rob Trautz, Christine Doughty, Sally Benson, Karsten Pruess, Curt Oldenburg, Jennifer Lewicki, Ernie Majer, Mike Hoversten, Mac Kennedy, Paul Cook
- Schlumberger: T. S. Ramakrishna, Nadja Mueller, Austin Boyd, Mike Wilt
- Oak Ridge National Lab: Dave Cole, Tommy Phelps, David Riestberg
- Lawrence Livermore National Lab: Kevin Knauss, Jim Johnson
- Alberta Research Council: Bill Gunter, John Robinson, Bernice Kadatz
- Texas American Resources: Don Charbula, David Hargiss
- Sandia Technologies: Dan Collins, "Spud" Miller, David Freeman; Phil Papadeas
- BP: Charles Christopher, Mike Chambers
- SEQUE – National Energy Technology Lab: Curt White, Rod Diehl, Grant Bromhall, Brian Stratizar, Art Wells
- Paulsson Geophysical – Bjorn Paulsson
- University of West Virginia: Henry Rausch
- USGS: Yousif Kharaka, Bill Evans, Evangelos Kakauros, Jim Thorsen
- Praxair: Joe Shine, Dan Dalton
- Australian CO2CRC (CSIRO): Kevin Dodds, Don Sherlock
- Core Labs: Paul Martin and others

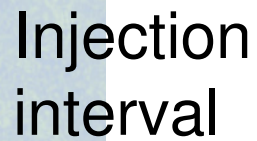


BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES

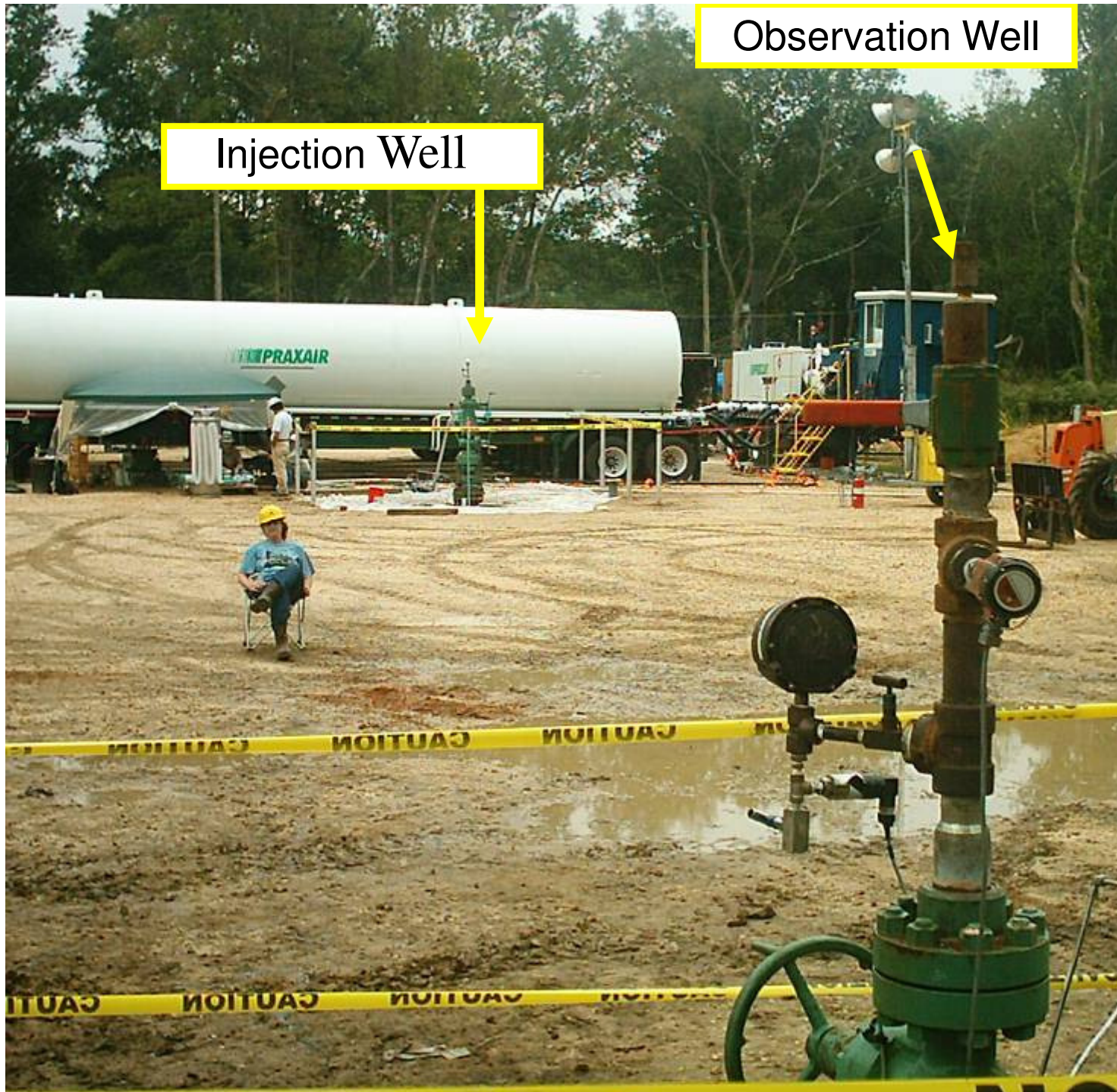


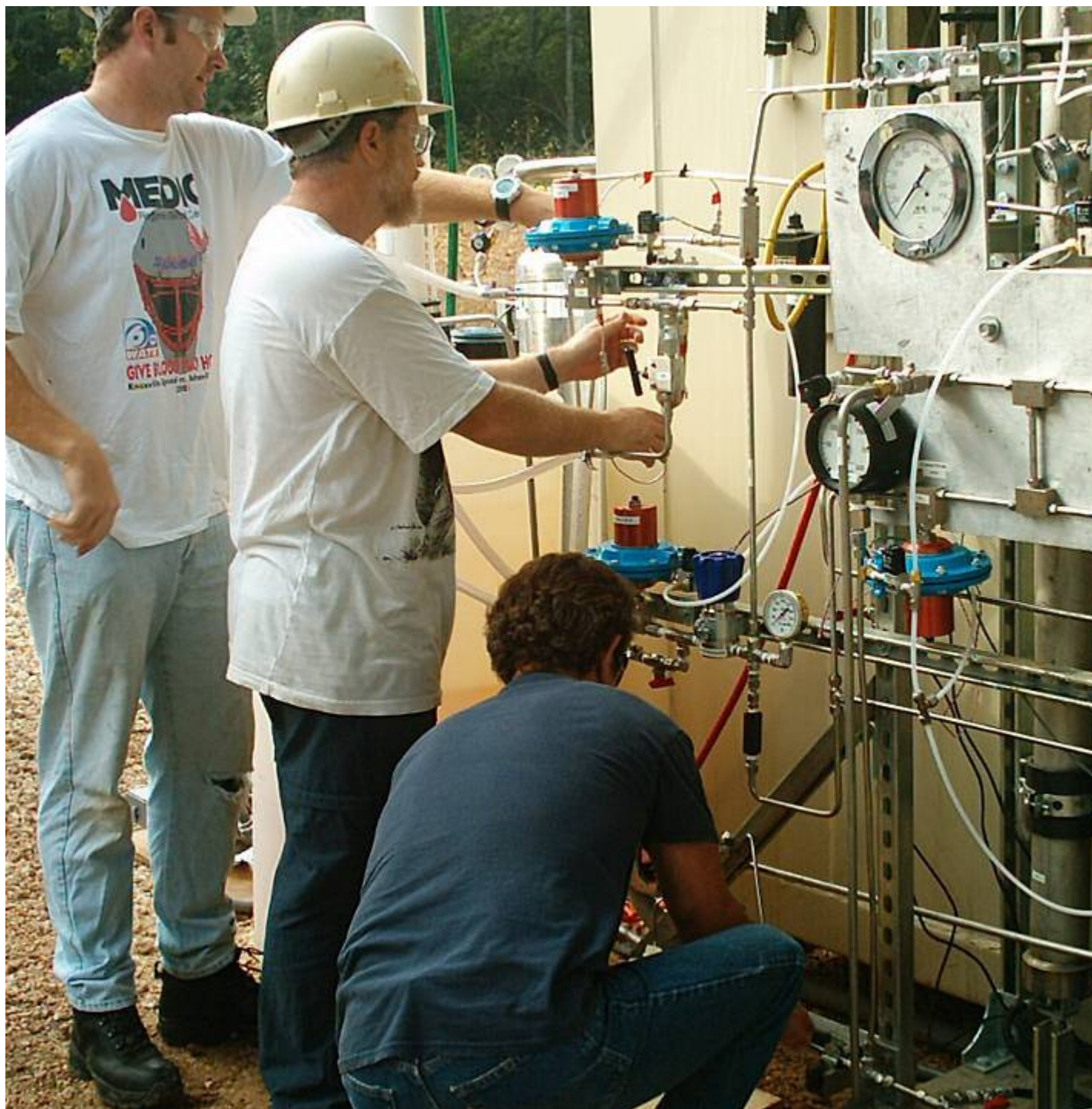
Frio Brine Pilot Site



Observation Well

Injection Well



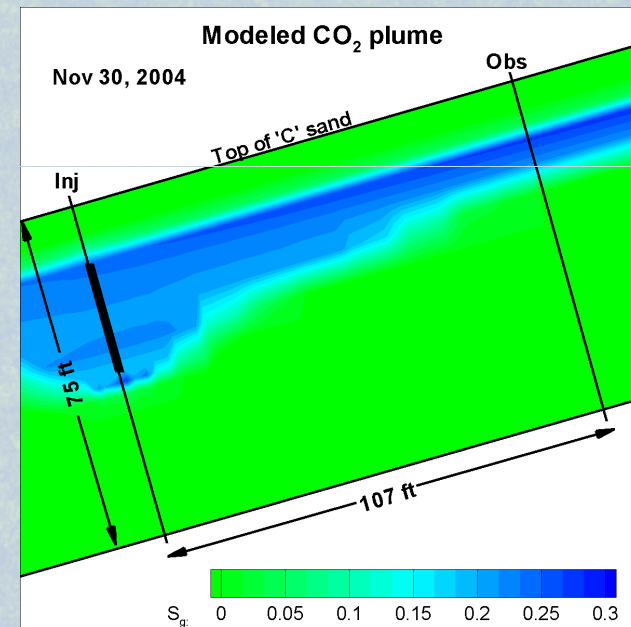
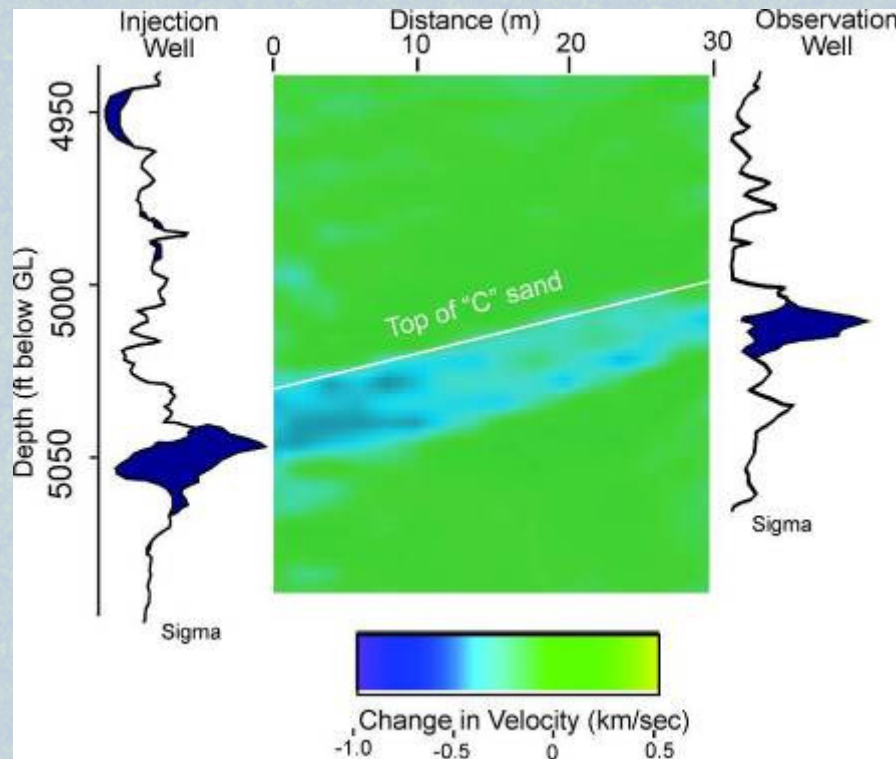


Tommy Phelps
Dave Ristenburg
Oak Ridge National Lab

Seay Nance
BEG



CO₂ Saturation Observed with Cross-well Seismic Tomography vs. Modeled



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES

Tom Daley and Christine Doughty LBNL



Frio I Pilot Injection Project 2005 - 2006

**First highly instrumented brine
injection**

**Showed ... computer simulation fate
of CO₂ work well**

**and available technologies can
monitor CO₂**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Frio II Pilot Injection Project 2007 - 2008

**Second highly instrumented
brine injection**

**Showed ... Capillary trapping of
CO₂ will be a significant factor is
assuring long term secure
storage**

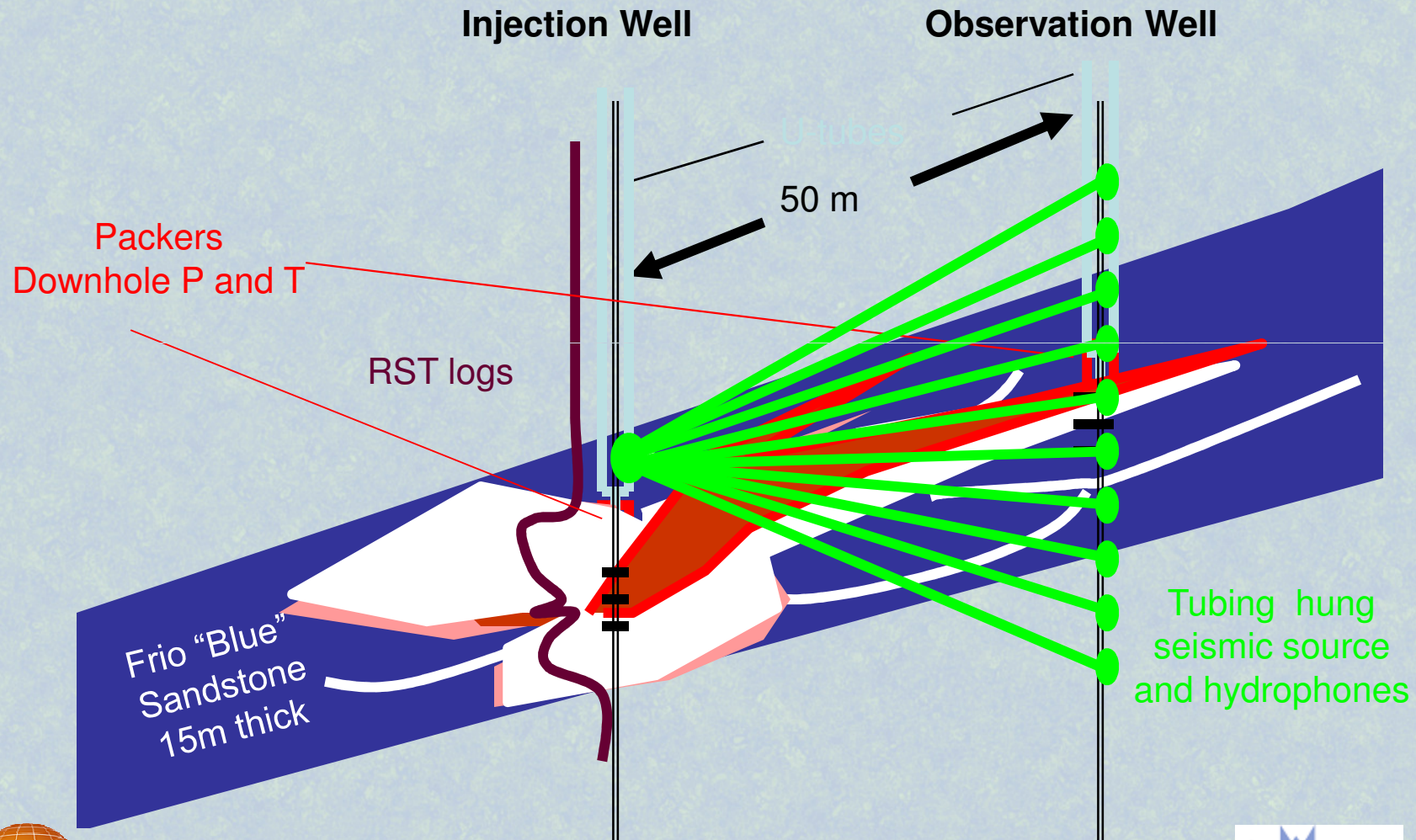


**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Monitoring Design Frio 2



BUREAU OF
ECONOMIC
GEOLOGY

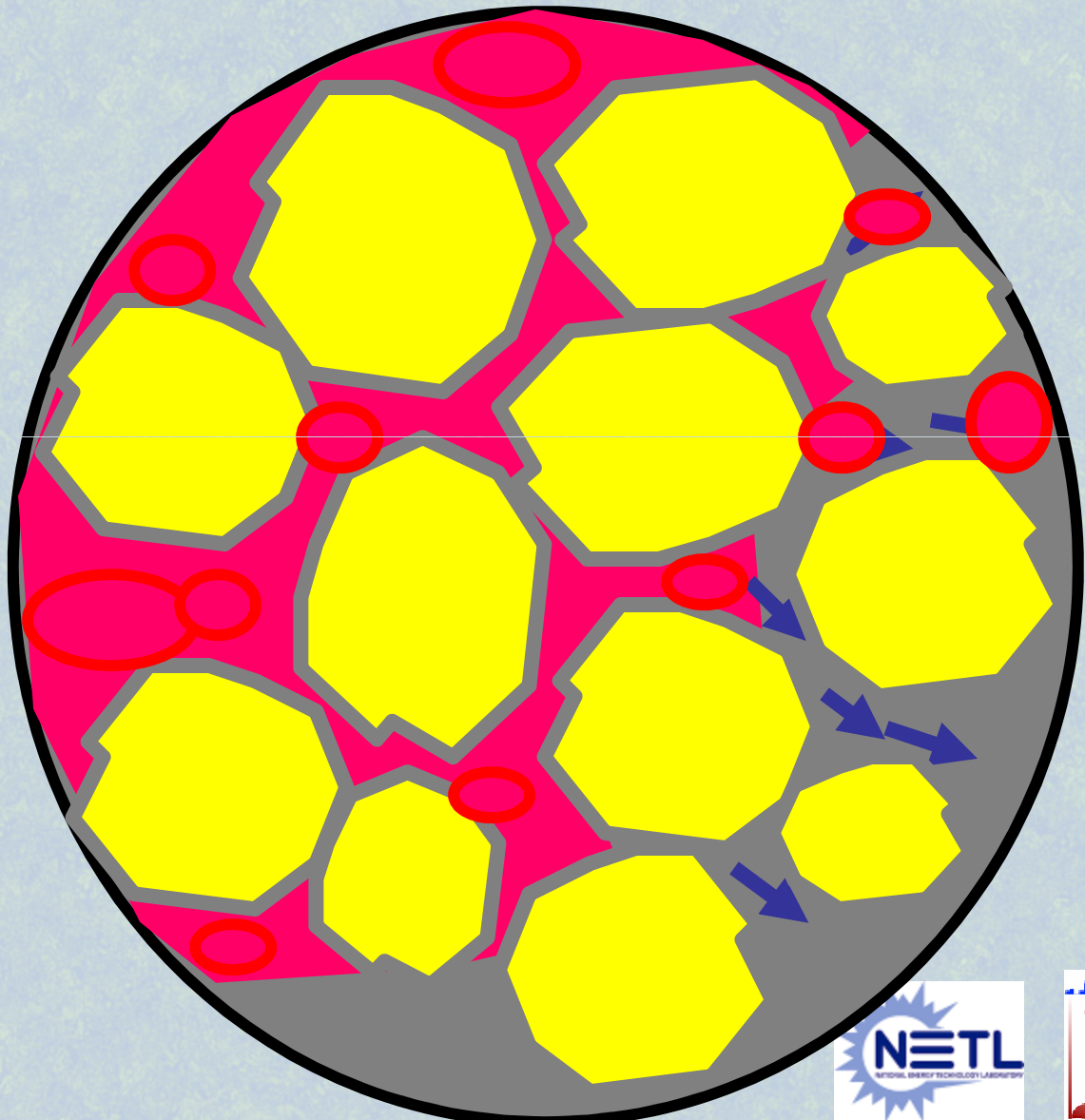
The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Two Phase Flow of CO₂ Brine

CO₂ is

- **non-wetting**
- **low viscosity**

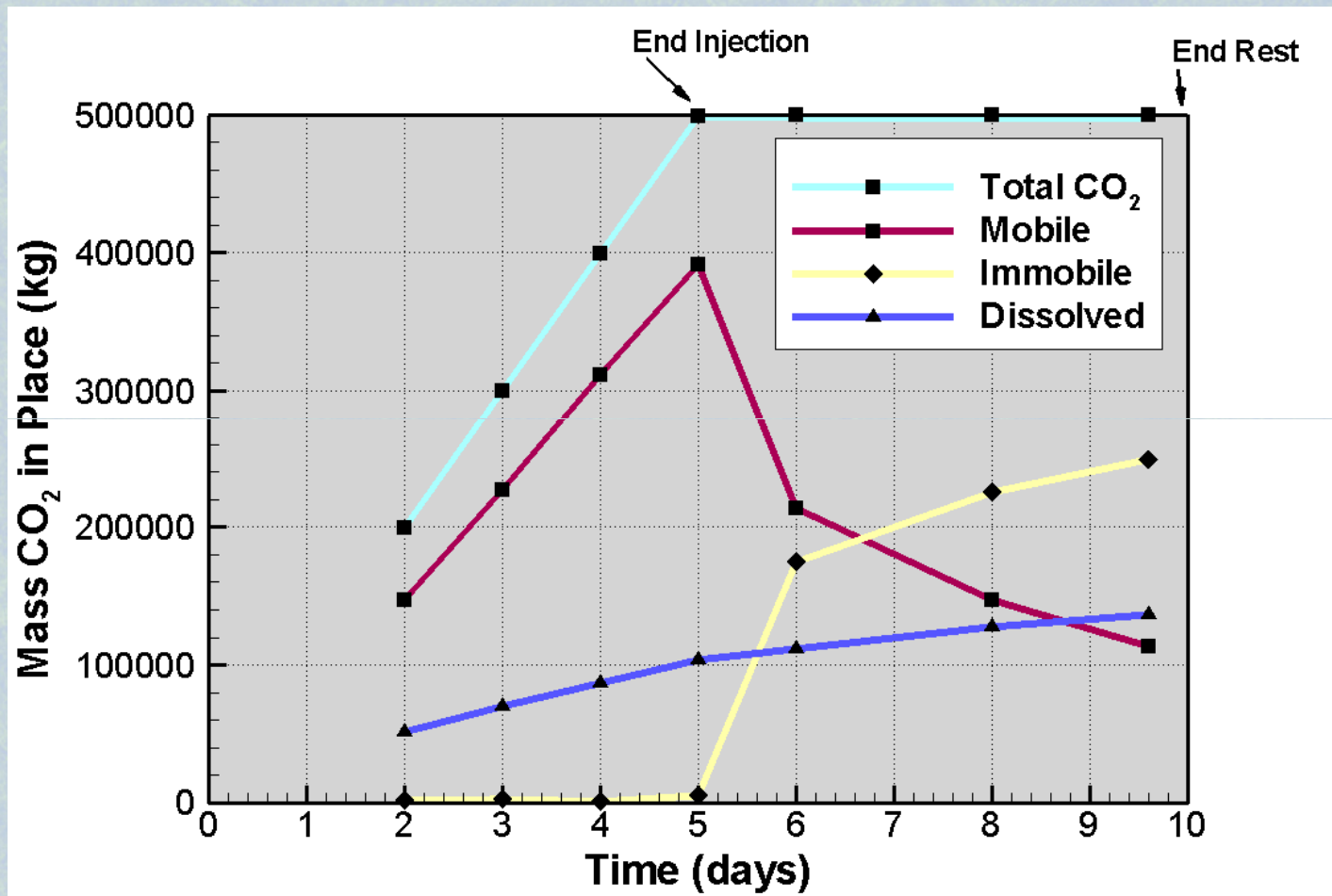


BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Modeled evolution of phases of CO₂



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



SACROC Project 2006 - 2010

**First monitoring for leakage in
Permian Basin CO₂ EOR site**

**Largest (over 80 million tons of
CO₂ injected over last 37 years)**

**SW Carbon Sequestration
Partnership Project hosted by
Kinder Morgan (EOR Operator)**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



SACROC Access to Private Water Wells



SACROC Project

**Showed No evidence of
leakage of CO₂ into groundwater**



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Cranfield Injection Projects



May 6th, 2010
Washington DC





Sandia Technologies



**LBNL
LLBL
USGS
ORNL
NETL
QEA**

**U Mississippi
Miss State
UTPGE
UT DoG
University Tennessee
BP
Princeton
Stanford
University Edinburgh**

**Schlumberger Carbon
Services**

**Gulf Coast Carbon
Center Staff**

Susan Hovorka
Ramon Trevino
Tip Meckel
Changbing Yang
Jiemin Liu

Katherine Romanak
Rebecca Smyth
Sigrid Clift
Masoumeh Kordi
Stuart Coleman
Yihua Cai
Hamid Lashgari

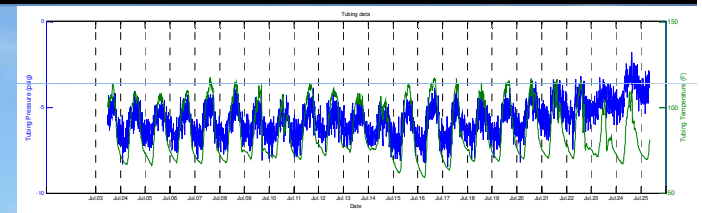
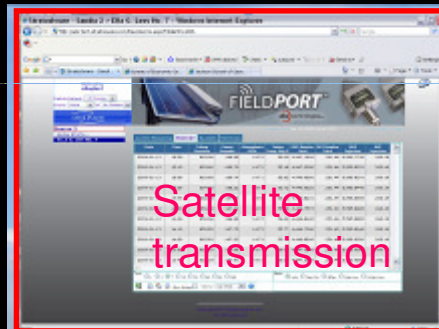
BEG staff

Tongwei Zhang
Jeff Paine
Bob Reedy
Robert Reed
Kitty Millikan

Cranfield Field Test Collaboration

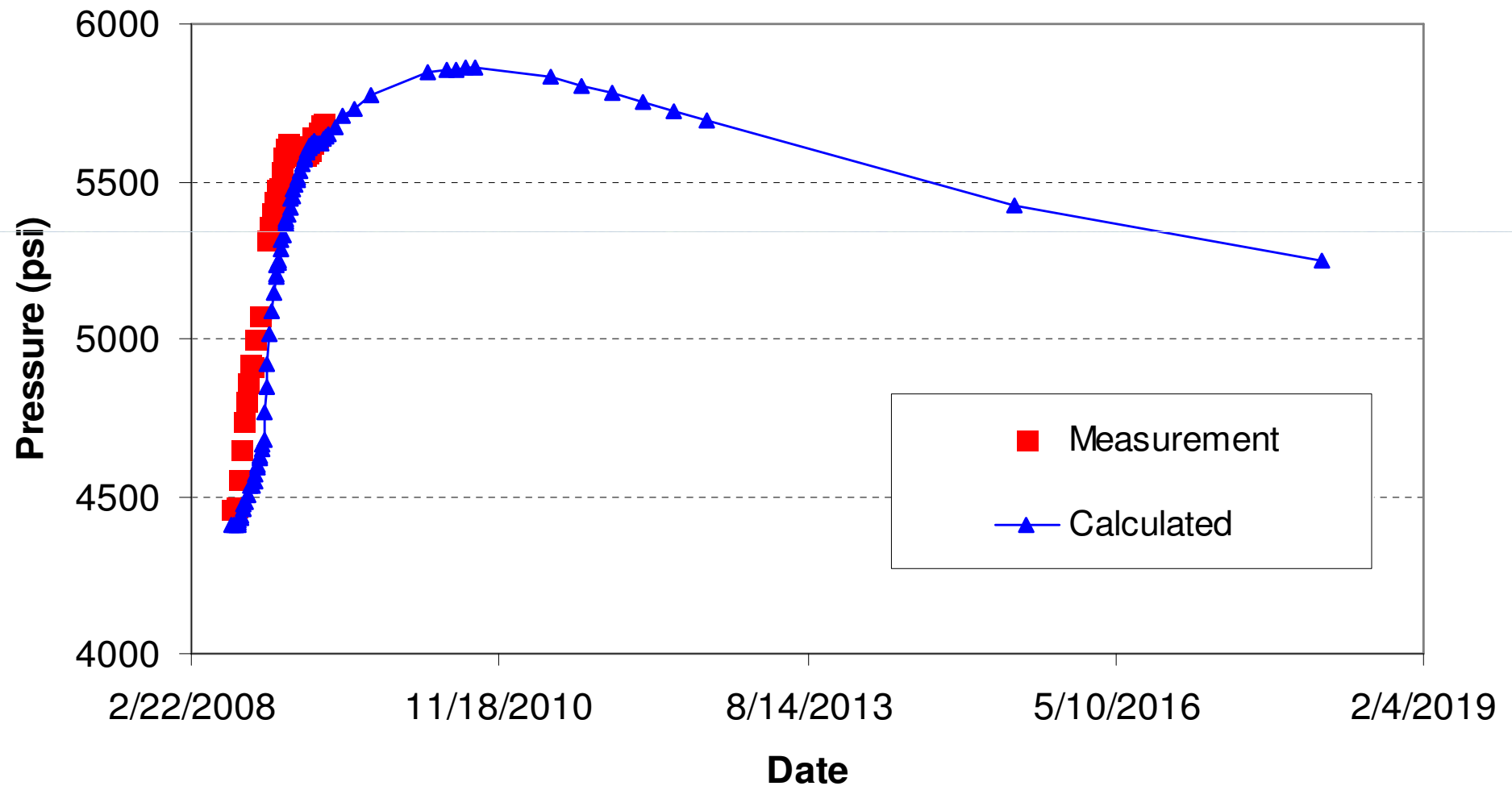
SECARB Partnership Project

Managed by SSEB



Pressure match at continuous monitoring well

BEG Observation well



Cranfield Phase II Project 2008 - 2010

**Million ton injection of CO₂ into
and oil field**

**SECARB Sequestration
Partnership Project hosted by
Denbury (EOR Operator)**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Cranfield Phase II Project 2008 - 2010

**Showed Digital pressure
gauges in reservoir and at well
head are sensitive to relatively
small leaks**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Cranfield Phase III Project 2009 - 2010

**First highly monitored million ton
a year injection rate into brine**

Project underway.....



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



IS CO₂ SEQUESTRATION SAFE?



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



IS CO₂ SEQUESTRATION SAFE?

Risks associated with CO₂ sequestration

Capture plant

CO₂ Pipelines

Well blowouts

Leakage of CO₂ into groundwater

Leakage of CO₂ into oil and gas reservoirs



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



CONCLUSIONS ABOUT RISKS

- **Most risks associated with CCS can be quantified and are similar to other analogous industrial activities**
- **Risks for well characterized, carefully selected sites are manageable and bounded**
- **Risk assessment ultimately is site specific**



BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



DO WE HAVE THE CAPACITY WE NEED?

Yes and no....

**Sequestration capacity is ample in
Gulf Coast, Illinois Basin,
California....**

**But limited in New England, Ohio
Valley, Mid Atlantic, Carolinas...**



**BUREAU OF
ECONOMIC
GEOLOGY**

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



CONCLUSIONS

CO₂ sequestration is ready for pilot projects at true commercial scale

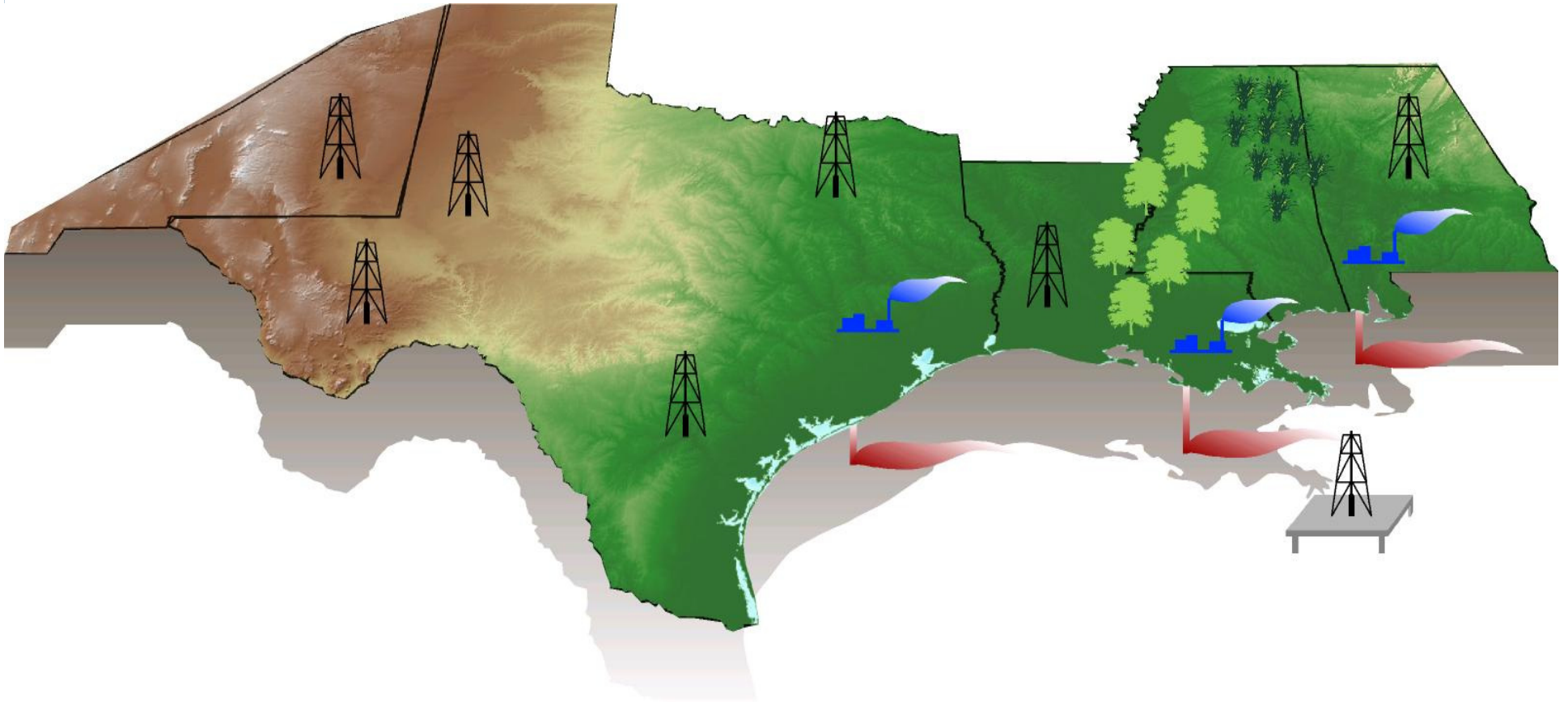


BUREAU OF
ECONOMIC
GEOLOGY

The University of Texas at Austin
John A. & Katherine G.
JACKSON
SCHOOL OF GEOSCIENCES



Thanks!



For more information: www.beg.utexas.edu